NBS TECHNICAL NOTE 590

A Preliminary Design of a Data Retrieval Language to Handle a Generalized Data Base: DRL

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A PRELIMINARY DESIGN OF A DATA RETRIEVAL LANGUAGE TO HANDLE A GENERALIZED DATA BASE: DRL

ELIZABETH FONG

DRL (Data Retrieval Language) is a high-level programming language for information retrieval. The language includes a data description language which can describe fixed-length hierarchical data structures, and DRL includes a data retrieval statement whereby a user can retrieve data by specifying conditions on to the data value. DRL also has an environment declaration statement in which the user can indicate specific peripheral devices by unit number for files. The rest of the language consists of an operation repertory of input-output functions and other data manipulations.

DRL is implemented as a preprocessor to FORTRAN V on the UNIVAC 1108, under EXEC II Operating system. Keywords act as triggers and are replaced by blocks of FORTRAN code.

The purpose of this project is to investigate the design of an information retrieval language to handle a generalized data base. The DRL system consists of a set of primitives utilizing both compile-time macros and run-time subroutines. These primitives are embedded in a high-level procedure-oriented programming language--the "host language" -- FORTRAN in this case. These primitives form a base upon which a class of languages can be defined.

Key words: Data base; data retrieval; data structure; information storage and retrieval; language extension; preprocessor; programming language.

I. Introduction

In implementing an information storage and retrieval system, one is faced with the problem of choosing a suitable programming language. Requirements of that programming language are:

- ability to define data structures
- ability to describe an environment
- ability to manipulate data structures
- ability to address data by content
- ability to offer computational power comparable to FORTRAN.

It is possible to implement information storage and retrieval system in procedure-oriented language such as ALGOL, FORTRAN, COBOL, or PL/1, but it is unnatural and requires indirectness in the use of primitives of the language. For example, let us consider writing a program to do the following simple task:

> Fine the first element of the array A, of length N, whose value is equal to 3 and set I equal to the value of the index. If none, set I equal to zero.

In a procedural-oriented language such as FORTRAN, one would say:

```
      DO 10 I = 1,N
      IF (A(I) .EQ. 3) GO TO 20
10    CONTINUE
      I = 0
20    . . .
```

Using languages such as LISP, SNOBOL, L6, etc., in doing information retrieval seems even more awkward. COBOL has file manipulation capability but lacks the ability of addressing data by content.[5] This leads to the notion of addressing data by content, which is more natural to a user, who is not a professional programmer. Hence the design of an information retrieval language should be convenient and natural for the user, yet the language should be powerful enough to handle complicated types of data structure. Such a language must have primitives at the level of what is to be done rather than how it is to be done.

An information retrieval language called DRL (Data Retrieval Language) has been designed and is partially implemented at the National Bureau of Standards to meet these objectives on an experimental basis. The DRL language is designed as an extension to FORTRAN explicitely to include the primitives necessary for an information retrieval language. The language will enable us to investigate the benefits of this approach to retrieval problems.

II. Brief Description of the Language

The DRL language is embedded in the FORTRAN V language system on the UNIVAC 1108 computer. It will allow all the usual FORTRAN capabilities plus the following four classes:

1. Input/Output statements
2. Data description statements
3. Data maintenance and manipulation statements
4. Data retrieval statements

II.1 Input/Output Commands

The input/output commands include the peripheral device declaration and also record accessing commands. The input/output devices permitted at present are card reader, card punch, printer, magnetic tape and drum. The logical unit number is the same as FORTRAN V standard table as set up at National Bureau of Standards, Gaithersburg.

a. ENVIRO

The ENVIRONMENT declaration provides information about the physical location of the data set associated with a file. This information allows the preprocessor to determine the method of accessing the data set, and causes the tape or drum to position at the beginning.

FORMAT

ENVIRO (<filename >, <logical unit no>)

<filename>::= A FORTRAN variable.

<logical unit no> ::= An integer variable/integer.

Allowable values for the logical unit numbers and their assignments are listed as follows:

LOGICAL UNIT	ASSIGNMENT
0	Reread
1	Card reader
2	Printer
3	Card punch
4	Console

5	Card reader
6	Printer
7 - 32	Tapes A - Z
33	Tape (
34	Tape -
35 and 36	Entire Drum 1300000 to 3777777 (octal)
37 and 38	Lower Half 1300000 to 2537777 (octal)
39 and 40	Upper Half 2540000 to 3777777 (octal)
41 and 42	Lower third 1300000 to 2177777 (octal)
43 and 44	Middle third 2200000 to 3077777 (octal)
45 and 46	Upper third 3100000 to 3777777 (octal)

EXAMPLE

ENVIRO (PAYROL, 35)

The above means declaring the entire drum as a mass storage device for a file called PAYROL.

b. PUTOUT

PUTOUT will write a record currently set up in core onto the indicated peripheral device. Unless a FORTRAN format label is supplied, the output is assumed to be binary.

FORMAT

PUTOUT (<where> , {<label> ,} <filename>)

<where>::= peripheral device unit number. It is assumed that the device is positioned to be written.

<filename>::= A FORTRAN variable.

<label>::= FORTRAN format label. This field is optional

EXAMPLE

```
PUTOUT (35, PAYROL)
```

or

```
PUTOUT (6,100, PAYROL)
100 FORMAT (1X , 22A6)
```

The first PUTOUT example means write out a record which is in main storage array PAYROL onto the previously positioned drum. The second PUTOUT example means write on the printer the record according to the FORTRAN format statement labeled 100.

c. GETIN

GETIN reads in a record from the indicated peripheral device onto the record image space in core. Unless a FORTRAN format label is supplied, the input is assumed to be binary.

FORMAT

GETIN (<where> , {<label> ,}<filename>)

<where>::= peripheral device unit number. It is assumed that the device is positioned to be read.

<filename>::= A FORTRAN variable.

<label>::= FORTRAN format label. This field is optional

EXAMPLE

```
GETIN (35, PAYROL)
```

or

```
GETIN (5, 100, PAYROL)
100 FORMAT (80A1)
```

The first GETIN example reads one record from the previously positioned drum into the main storage array PAYROL. The second GETIN example reads from the card reader according to FORTRAN format statement labeled 100 into the array PAYROL.

II.2 Data Description Commands

Facility for declaring hierarchically structured data is provided. The declaration format is patterned after PL/1 where the level of hierarchy is indicated by the level number in front of the variables in the declaration. When the variable occurs without the level number in front, it is assumed that the declaration is merely a single data item or an array. To facilitate character manipulation, the string declaration is added to the FORTRAN type statements.

a. DECLAR CHARAC or BITS

DECLAR with the data type CHARAC means the variable being declared is a string of n six-bit Fieldata code as defined for the UNIVAC 1108. DECLAR with the data type BITS means the variable being declared is of n bits taking on values one or zero.

FORMAT

DECLAR (<variable> CHARAC (<n>))

DECLAR (<variable> BITS (<n>))

<variable> ::= A FORTRAN Variable.

<n> ::= An integer greater than 0.

EXAMPLES

```
DECLAR ( NAME CHARAC (10))
DECLAR ( MATRIX  BITS (8))
```

b. DECLAR hierarchically

DECLAR with a hierarchical data list declares a data structure consisting of elementary data items (terminal nodes) and composite data items (non-terminal nodes or meta syntactical variable). The composite data items must have one or more subordinates and the elementary data items must have data type and size specifications associated with them.

FORMAT

DECLAR (<hierarchical data list>)

<hierarchical data list>::= <hierarchical data>/

<hierarchical data list>, <hierarchical data>

<hierarchical data>::= <n> <variable>/

<n> <variable> <type> <dimension>

<type>::= all legal FORTRAN data types (only first six characters) plus CHARAC and BITS

<dimension>::= (<n>)

<variable>::= A FORTRAN variable

<n>::= An integer greater than 0

EXAMPLE

```
DECLAR ( 0 PAYROL,
           1  NAME,
              2  FIRST CHARAC (10),
              2  MIDDLE CHARAC (10),
              2  LAST CHARAC (10),
           1  SALARY,
              2  REGU INTEGE (1),
              2  OVER INTEGE (1),
           1  OCC CHARAC (20) )
```

II.3 Data Maintenance and Manipulation Commands

a. PUT

PUT assumes a data structure into which values are to be stored. If the attribute name happens to be an elementary data item, then the value is simply put in. If the attribute is not an elementary data item, then the lists of values to fill the attributes subordinate to it must be given.

FORMAT

PUT (<attribute>, <value list>)

<attribute>::= elementary data item variable or composite data item variable as declared in DECLAR statement

<value list> ::= <value>/<value list>, <value>

<value>::= any expression (The present version can only handle constants, literals and variables)

EXAMPLE

The following example assumes the declaration which appears in the DECLAR hierarchically example given above.

```
PUT (LAST, 'FONG')
PUT (NAME, 'LIZ', 'NEE', 'FONG')
```

The first PUT expression whose first argument is the elementary data item LAST and therefore the value is immediately assigned. In the second PUT expression the first argument is the composite data item NAME consisting of three subordinates and therefore the three values 'LIZ', 'NEE', and 'FONG' are assigned to FIRST, MIDDLE and LAST respectively.

b. LOCATE

Records within a file have an ordinal number according to their position within the file. LOCATE positions the file with respect to this ordinal number of the record.

FORMAT

LOCATE (<filename>, <index>)

<filename> ::= A FORTRAN variable defined in ENVIRO and DECLAR statements

<index> ::= An integer / An integer variable. If index = 0 the file is position to the beginning of the file.

EXAMPLE

LOCATE (PAYROL, 5)

LOCATE (PAYROL, IXGET)

c. DELETE AND DELIX

DELETE deletes the first encountered record which satisfies the given condition list.

DELIX deletes the Nth record in the file where N is given.

FORMAT

DELETE (<filename> , <condition list>)

DELIX (<filename >, <index>)

<condition list> ::= This is the same as described under the Get command

<filename> ::= A FORTRAN variable defined in ENVIRO and DECLAR statements

<index> ::= An integer / An interger variable

EXAMPLE

The following example assumes the declaration which appears in the DECLAR (hierarchically) example.

```
DELETE (PAYROL, LAST EQ 'SMITH')

DELIX (PAYROL, 5)
```

II.4 Data Retrieval Commands

a. GET

GET is a retrieval function which returns the value of the specified attribute in the first encountered record which satisfies the given conditions.

FORMAT

A = GET (< filename> , <attribute> , < condition list>)

< filename> ::= A FORTRAN variable declared in ENVIRO and DECLAR statements. It is assumed that the peripheral device is positioned to start searching.

<attribute> ::= Elementary data item variable or complex data item variable as declared in DECLAR statement.

< condition list > ::= < wff >

< wff> ::= <proposition> / < wff><connectives><wff>

<proposition > ::= < attribute><rel><value>

<connectives > ::= AND / OR

<rel > ::= EQ / NE / GT / GE / LT / LE

<value> ::= Any expression

EXAMPLE

The following example assumes the declaration which appears in the DECLAR (hierarchically) example.

```
A = GET ( PAYROL, NAME, REGU EQ 400 AND OCC EQ 'MATH' )
```

This GET command will search the PAYROL file. If the field REGU equal 400 and the field OCC equals MATH, then the field NAME will be retrieved and stored in A. A must be properly dimensioned.

DEFAULT CONDITIONS

If an error occurs, RUNERR routine is executed. RUNERR is a routine which may be supplied by the user to handle error recovery. If the user does not supply a RUNERR routine, the DRL system will execute the UNIVAC EXEC II error routine which will just stop execution.

REMARK

If there is no second argument of the GET command, i.e., two commas with nothing in between, then it is assumed that the index value is required. In any case an internally defined variable called IXGET will always contain the index value after each GET function. The IXGET value will be destroyed upon initiation of the next GET function.

b. GETALL

GETALL is the same as GET except instead of retrieving a single item, a whole set is retrieved. The variable occurring on the left of the GETALL statement must be pre-declared as one dimensional array with an estimate of maximum size. After retrieving, the first entry of that array will contain the count of the number of items retrieved followed by the values. The user must also DIMENSION the IXGET to be one dimensional array of maximum size. After each execution of GETALL, IXGET (1)

contains the count of the number of items retrieved followed by the list of pointer to the retrieved records.

II.5 Higher Order Functions

These functions could be defined by combining appropriate previously defined primitive functions.

a. REPLACE

REPLACE may be defined by combining the following four DRL primitives.

GET - get a whole record that meets given conditions

PUT - change value as desired

LOCATE - position back

PUTOUT - put back the modified record in the file.

b. SUBSET

SUBSET may be defined by the following pseudo statements.

ENVIRO - declared a different unit number for a subfile

10 GET - get a record that meets the given conditions

IF end-of-file THEN stop

PUTOUT - putout on the new unit

GO TO 10

An alternative way of defining assumes the existence of the primitive MOVE. This may be defined as a user's subroutine.

ENVIRO - declare a different unit number for a subfile

GETALL - get all records that meets the given conditions

MOVE - move to individual buffers for a unit record

PUTOUT - putout on the new unit.

c. COUNT

COUNT may be defined with the GETALL command and reading out the first word of the IXGET array or the user-defined array containing the answers.

II.6 Built-in String Manipulation Functions

There exists in the DRL system a group of run-time subroutines which are accessible to the user. The following is a set of string i.e., characters manipulation functions which are patterned after PL/1. The string variables must be declared as characters in a DECLAR CHARAC statement.

CONC (A.B) is the concatenation of string A and B.

LENGTH (A) is the length of string A.

INDEX (A, 'B') returns the starting location for the first occurrence of 'B' in string A or zero if not found.

SUBSTR (A, I, J) extracts the substring starting at position I of length J. If J equals 0 the rest of String A is returned.

MATCH (A,B,N) compares the first N characters of A to B. If they are identical, the value of MATCH is true, otherwise the value of MATCH is false.

III. Method of Implementation

The DRL language translator is a preprocessor to FORTRAN V on the UNIVAC 1108. It consists of two major phases:

Phase 1 - A scanner reads the input stream and traps all the DRL keywords and replaces them with appropriate blocks of FORTRAN code.

The declarative statements generate FORTRAN dimensioning statements and tables containing the data descriptions.

Phase 2 - A collection of predefined run-time subroutines to perform all of the above described tasks.

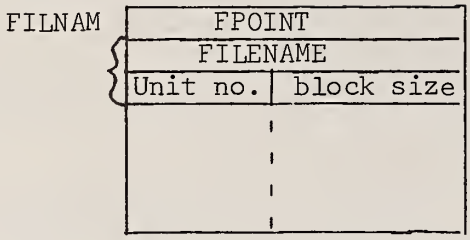
Both phase 1 and phase 2 work. All of the primitives defined above have been implemented. The higher order functions have not been implemented.

The main routine is the lexical scanner called LSCAN. This routine reads the DRL statements and branches according to the keywords scanned. The DRL syntax conforms to the FORTRAN statement format. If a given statement does not contain a DRL keyword, then it is assumed to be a FORTRAN statement, and the line is carried over to the generated program. The DRL keyword analysis is described individually as follows:

a. DROP - This should be the first statement of the DRL program. The operand of this statement defines a name for the output FORTRAN source.

b. ENVIRO - This statement generates the equivalent of an open file statement by positioning the peripheral device indicated by the unit number to the beginning. The file name is entered into the FILNAM table.

Layout of FILNAM table



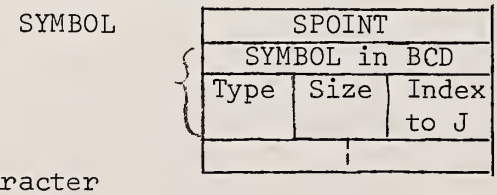
c. DECLAR - This generates FORTRAN DIMENSION statements. If it is hierarchical data declaration, then it generates DIMENSION statements and EQUIVALENCE statements for all the complex data item names. Also the hierarchical data information is stored in the 8-column matrix J. The meaning of these 8 columns are as follows:

J(I,1) contains the hierarchical level number
J(I,2) contains the BCD symbol table index number
J(I,3) contains the degree or number of subtrees of that node
J(I,4) contains the index no. of the parent node
J(I,5) contains the index no. of the sister node
J(I,6) contains the next occupant of the same name
J(I,7) contains the size in characters
J(I,8) contains the starting character position from the beginning.

The details of the J-matrix can be found in Lawson [2].

The variable names are also entered into the SYMBOL table.

Layout of SYMBOL table



Type = 1 means character

Type = 2 means BITS

Type = 0 means other

SIZE = no. of characters or bits.

d. PUTOUT - This generates an appropriate output statements including calls to NTRAN if the output is to be binary. NTRAN is a FORTRAN callable subroutine which provides buffered input/output routines for tape and drum. Detailed description of NTRAN can be found in section 7.5 of the UNIVAC 1107 FORTRAN manual [3].

e. GETIN - This is the same as PUTOUT except it generates appropriate output statements.

f. GET - This will first generate a NTRAN call to read in a record. A boolean function containing the conditions given is next generated. On the 'true' branch the extraction of the specified attribute code is supplied. On the 'false' branch, a GOTO statement back to the NTRAN call to read in the next record is generated.

g. GETALL - Same as GET except a loop is set up to continuing retrieving until an end of file is reached.

h. PUT - This will generate a DO Loop containing a call to a run-time routine called MOVECH. MOVECH will move a character from the indicated source to the indicated destination.

i. LOCATE - This will generate a NTRAN call to position the peripheral device N records from the beginning. If the device is drum, the drum address is positioned from the beginning by the amount N times the length of the record.

j. DELETE - (This command is to be used primarily with drum) This statement will first call GET to determine which record meets the conditions given. Then it calls LOCATE to position the file to this record. The record is then zeroed. Garbage collection

is not yet coded.

k. DELIX - (This command is to be used primarily with drum). This first calls LOCATE to position the file to the Nth record, and the record is zeroed.

IV. Operation

The input to the DRL translator is the program text written in the DRL language. The output is a FORTRAN program automatically residing on the drum, linked-edited, and ready to be executed. This output FORTRAN program, together with the predefined run-time action routines and block data, will be the final executable program capable of manipulating data, accessing the peripheral storage and performing any kind of retrieval tasks. This present version consists of approximately 1900 lines of FORTRAN and approximately 300 lines of UNIVAC assembly code.

The source listing of the entire DRL system is available from the author upon request.

The author is deeply indebted to Mr. Charles T. Meadow for first suggesting the topic and for his interest throughout the implementation.

V. References

[1] UNIVAC 1108 FORTRAN V-Programmer's Reference Manual UP4060, Sperry Rand Corporation, 1966.

[2] Lawson, Harold W., Jr., "The Use of Chain List Matrices for the Analysis of COBOL Data Structures," presented at the ACM National Conference, 1962.

[3] UNIVAC 1107 FORTRAN IV - Programmer's Reference Manual, UP-3569, Sperry Rand Corporation, 1966.

[4] IBM System/360 PL/1 Reference Manual, File No. S 360-29, Form No. C 28-8201-1, IBM 1968.

[5] Hanlon, A.G., "Content - Addressable and Associative Memory Systems - A Survey", IEEE Transaction on Electronic Computers, vol. EC-15, No. 4, August, 1966.

APPENDIX A -- A Sample Run of DRL

In this appendix, the following three outputs are presented:

(1) DRL sample program. These DRL statements are translated into FORTRAN codes which appear indented to the right. The data description table, symbol table, and file name table are generated as FORTRAN assignment statements.

(2) FORTRAN compilation of the DRL generated program.

(3) Execution of the sample program. The sample program reads in from the card reader a file of personnel records. It sets up the data base on drum. Two retrieval commands are executed.

```
 1*       OROP ABC
                                          IMPLICIT INTEGER (A-Z)
 2*       ENVIRO (PAYROL,35)
                                          CALL  NTRAN(    35, 10 )
 3*       OECLAR (O PAYROL,
 4*      X   -        1 NAME,
 5*      X              2 FIRST CHARAC (12),
 6*      X              2 MIOOLE CHARAC (12),
 7*      X              2 LAST CHARAC (12),
 8*      X            1 SALARY,
 9*      X              2 REGULR INTEGE (1),
10*      X              2 OVER INTEGE (1) )
                                          DIMENSION   PAYROL  (        9)

                                          EQUIVALENCE(NAME  ,     PAYROL)
                                          EQUIVALENCE(FIRST ,     PAYROL)
                                          EQUIVALENCE(MIOOLE,     PAYROL)
                                          EQUIVALENCE(LAST  ,     PAYROL)
                                          EQUIVALENCE(SALARY,     PAYROL)
                                          EQUIVALENCE(REGULR,     PAYROL)
                                          EQUIVALENCE(OVER  ,     PAYROL)
                                          COMMON/MATRIX/INO,ILIM,SP,J(50,8)
                                          COMMON/STABLE/SYMBOL(200),FILNAM(20)
                                          LOGICAL TESTRL
                                          GO TO      1
                                      2   CONTINUE
11*      OECLAR (ANS CHARAC (36))
                                          DIMENSION   ANS     (        7)

12*      ANS (7)='
                                          ANS (7)='
13*      OO 600 I=1,7
                                          OO 600 I=1,7
14*      GETIN (5,500,PAYROL)
                                          READ (5,       500)     PAYROL
15*  500 FORMAT (3(A6,A4), 2I6,A6)
                                      500 FORMAT (3(A6,A4), 2I6,A6)
16*      PUTOUT (6,501,PAYROL)
                                          WRITE(6,       501)     PAYROL
17*  501 FORMAT (1X, 'NAME=', 3(A6,A4), ' REG=', I6, ' OVER=', I6)
                                      501 FORMAT (1X, 'NAME=', 3(A6,A4), ' REG=', I6, ' OVER=', I6)
18*      PUTOUT (35,PAYROL)
                                          ST=1
                                          CALL NTRAN (    35,1,        9,     PAYROL,ST)
                                          CALL CHECKS (ST, $     3)
                                          GO TO      4
                                        3 WRITE (6,        5)
                                        5 FORMAT(1X,11HEND OF FILE)
                                          CALL  RUNERR
                                        4 CONTINUE
19*  600 CONTINUE
                                      600 CONTINUE
20*      LOCATE (PAYROL,O)
                                          CALL  NTRAN(    35, 10)
21*      ANS=GET (PAYROL.NAME,LAST EQ 'LEAR')
                                          IXGET=0
                                          ST=1
                                          ANS   (1)=0
                                        6 IXGET=1XGET+1
                                          CALL  NTRAN(    35,2,        9,     PAYROL,ST)
                                          CALL CHECKS (ST, $     7)
                                          IF (        TESTRL(I,'LAST  ',LAST  ,'LEAR'))GOTO     8
                                          GO TO      6
                                        8 CALL SUBSTR(PAYROL,    9,    I,   36,     ANS   ,   36)
                                        7 CONTINUE
22*      PUTOUT (6,502,ANS)
                                          WRITE(6,       502)     ANS
23*  502 FORMAT (1HO,1X, 'NAME WHERE LAST EQ LEAR =', 7A6)
                                      502 FORMAT (1HO,1X, 'NAME WHERE LAST EQ LEAR =', 7A6)
24*      LOCATE (PAYROL,O)
                                          CALL  NTRAN(    35, 10)
25*      ANS=GET(PAYROL,NAME,REGULR GT 700)
                                          IXGET=0
                                          ST=1
                                          ANS   (1)=0
                                        9 IXGET=1XGET+1
                                          CALL  NTRAN(    35,2,        9,     PAYROL,ST)
                                          CALL CHECKS (ST, $     10)
                                          IF (        TESTRL(3,'REGULR',REGULR,700   ))GOTO    11
                                          GO TO      9
                                       11 CALL SUBSTR(PAYROL,    9,    I,   36,     ANS   ,   36)
                                       10 CONTINUE
26*      PUTOUT (6,503,ANS)
                                          WRITE(6,       503)     ANS
27*  503 FORMAT (1HO,1X,'NAME WHERE REG GT 700=', 7A6)
                                      503 FORMAT (1HO,1X,'NAME WHERE REG GT 700=', 7A6)
28*      STOP
                                          STOP
29*      ANS=GETALL (PAYROL,NAME,OVER GT 500)
                                          I=1
                                          IXGET=0
                                          ST=1
                                          ANS   (1)=0
                                       12 IXGET=1XGET+1
                                          CALL  NTRAN(    35,2,        9,     PAYROL,ST)
                                          CALL CHECKS (ST, $     13)
                                          IF (        TESTRL(3,'OVER  ',OVER  ,500   ))GOTO    14
                                          GO TO      12
                                       14 CALL SUBSTR(PAYROL,    9,    1,   36,     ANS   (I+  6),  3A)
                                          ANS   (1)=  ANS   (I)+1
                                       13 CONTINUE
30*      END
                                          STOP
                                      1   CONTINUE
                                          ILIM =     ID
                                          J (         1     ,     1)  =        0
                                          J (         1     ,     2)  =        2
                                          J (         1     ,     3)  =        2
                                          J (         1     ,     4)  =        0
                                          J (         1     ,     5)  =        9
                                          J (         1     ,     6)  =       6M@@@@@@
                                          J (         1     ,     7)  =       48
                                          J (         1     ,     8)  =        0
                                          J (         2     ,     1)  =        1
                                          J (         2     ,     2)  =        4
                                          J (         2     ,     3)  =        3
```

```
J (          2     ,     4)  =        1
J (          2     ,     5)  =        6
J (          2     ,     6)  =      6H@@@@@@
J (          2     ,     7)  =       36
J (          2     ,     8)  =        0
J (          3     ,     1)  =        2
J (          3     ,     2)  =        6
J (          3     ,     3)  =        0
J (          3     ,     4)  =        2
J (          3     ,     5)  =        4
J (          3     ,     6)  =      6H@@@@@@
J (          3     ,     7)  =       12
J (          3     ,     8)  =        0
J (          4     ,     1)  =        2
BEFORE CALLING ORUM WRITE
ORUM WRITE CALLED
J (          4     ,     2)  =        8
J (          4     ,     3)  =        0
J (          4     ,     4)  =        2
J (          4     ,     5)  =        5
J (          4     ,     6)  =      6H@@@@@@
J (          4     ,     7)  =       12
J (          4     ,     8)  =       12
J (          5     ,     1)  =        2
J (          5     ,     2)  =       10
J (          5     ,     3)  =        0
J (          5     ,     4)  =        2
J (          5     ,     5)  =        3
J (          5     ,     6)  =      6H@@@@@@
J (          5     ,     7)  =       12
J (          5     ,     8)  =       24
J (          6     ,     1)  =        1
J (          6     ,     2)  =       12
J (          6     ,     3)  =        2
J (          6     ,     4)  =        1
J (          6     ,     5)  =        2
J (          6     ,     6)  =      6H@@@@@@
J (          6     ,     7)  =       12
J (          6     ,     8)  =       36
J (          7     ,     1)  =        2
J (          7     ,     2)  =       14
J (          7     ,     3)  =        0
J (          7     ,     4)  =        6
J (          7     ,     5)  =        8
J (          7     ,     6)  =      6H@@@@@@
J (          7     ,     7)  =        6
J (          7     ,     8)  =       36
J (          8     ,     1)  =        2
J (          8     ,     2)  =       16
J (          8     ,     3)  =        0
J (          8     ,     4)  =        6
J (          8     ,     5)  =        7
J (          8     ,     6)  =      6H@@@@@@
J (          8     ,     7)  =        6
J (          8     ,     8)  =       42
J (          9     ,     1)  =        0
J (          9     ,     2)  =       18
J (          9     ,     3)  =        0
J (          9     ,     4)  =        0
J (          9     ,     5)  =       10
J (          9     ,     6)  =      6H@@@@@@
J (          9     ,     7)  =       36
J (          9     ,     8)  =        0
J (         10     ,     1)  =        0
J (         10     ,     2)  =       20
J (         10     ,     3)  =        0
J (         10     ,     4)  =        0
J (         10     ,     5)  =        0
J (         10     ,     6)  =      6H@@@@@@
J (         10     ,     7)  =        6
J (         10     ,     8)  =       36
SYMBOL(          1)  =      6H@@@@@@
SYMBOL(          2)  =      6HPAYROL
SYMBOL(          3)  =      6H@@@@@C
SYMBOL(          4)  =      6HNAME
SYMBOL(          5)  =      6H@@@@@J
SYMBOL(          6)  =      6HFIRST
SYMBOL(          7)  =      6H@C@GG*
SYMBOL(          8)  =      6HMIDDLE
SYMBOL(          9)  =      6H@C@GG&
SYMBOL(         10)  =      6HLAST
SYMBOL(         11)  =      6H@C@GG
SYMBOL(         12)  =      6HSALARY
SYMBOL(         13)  =      6H@@@A@A
SYMBOL(         14)  =      6HREGULR
SYMBOL(         15)  =      6H@@@AGB
SYMBOL(         16)  =      6HOVER
SYMBOL(         17)  =      6H@@@@@C
SYMBOL(         18)  =      6HANS
SYMBOL(         19)  =      6H@C@*@O
SYMBOL(         20)  =      6HOUHMY
SYMBOL(         21)  =      6H@@@@@E
SYMBOL(         22)  =      6H@@@@@@
FILNAM(          1)  =      6H@@@@@&
FILNAH(          2)  =      6HPAYROL
FILNAM(          3)  =      6H@@<W@O
FILNAH(          4)  =      6M@@@@@@
GO TO      2
END
ORUH WRITE CALLED
```

```
@IT FOR,• ABC,ABC
UNIVAC 1108 FORTRAN V LEVEL   22n6 0018 FS01aP
THIS COMPILATION WAS DONE ON 03 JUN 71 AT 14:1n:19

   MAIN PROGRAM

   STORAGE USED (BLOCK, NAME, LENGTH)

       0001   •CODE    000543
       0000   •DATA    000142
       0002   •BLANK   000000
       0003   MATRIX   000623
       0004   STABLE   000334


   EXTERNAL REFERENCES (BLOCK, NAME)

       0005   NTRAN
       0006   TESTRL
       0007   CHECKS
       0010   RUNERR
       0011   SUBSTR
       0012   NROUS
       0013   NIO1S
       0014   NIO2S
       0015   NWOUS
       0016   NSTOPS


   STORAGE ASSIGNMENT FOR VARIABLES (BLOCK, TYPE, RELATIVE LOCATION, NAME)

    0001   000277 1L          0001   000210 10L         0001   000200 11L         0001   000214 12L         0001   000136 124G
    0001   000275 13L         0001   000016 130G        0001   000030 137G        0001   000257 14L         0001   000136 175G
    0001   000005 2L          0001   000216 220G        0001   000052 3L          0001   000061 4L          0000   000027 5F
    0000   000013 500F        0000   000016 501F        0000   000037 502F        0000   000050 503F        0001   000072 6L
    0001   000130 7L          0001   000120 8L          0001   000152 9L          0000 1 000000 ANS         0004 1 000310 FILNAM
    0000   000061 FIRST       0000 1 000007 I           0003 I 000001 ILIM        0003 1 000000 IND         0000 1 000012 IXGET
    0000 1 000010 IS          0003 1 000003 J           0000 I 000061 LAST        0000   000061 MIDDLE      0000   000061 NAME
    0000 1 000061 OVER        0000 1 000061 PAYROL      0000 I 000061 REGULR      0000   000061 SALARY      0003 I 000002 SP
    0000 1 000011 ST          0004 I 000000 SYMBOL      0006 L 000000 TESTRL


00101     1•          IMPLICIT INTEGER (A-Z)
00103     2•          CALL  NTRAN(    35, 10 )
00104     3•          DIMENSION   PAYROL  (        9)
00105     4•
00105     5•          EQUIVALENCE(NAME  ,     PAYROL)
00106     6•          EQUIVALENCE(FIRST ,     PAYROL)
00107     7•          EQUIVALENCE(MIDDLE,     PAYROL)
00110     8•          EQUIVALENCE(LAST  ,     PAYROL)
00111     9•          EQUIVALENCE(SALARY,     PAYROL)
00112    10•          EQUIVALENCE(REGULR,     PAYROL)
00113    11•          EQUIVALENCE(OVER  ,     PAYROL)
00114    12•          COMMON/MATRIX/IND,ILIM,SP,J(50,8)
00115    13•          COMMON/STABLE/SYMBOL(200),FILNAM(20)
00116    14•          LOGICAL TESTRL
00117    15•          GO TO      1
00120    16•      2   CONTINUE
00121    17•          DIMENSION   ANS     (        7)
00122    18•
00122    19•          ANS (7)='       '
00123    20•          DO 600 I=1,7
00126    21•          READ (5,       500)     PAYROL
00134    22•      500 FORMAT (3(A6,A4), 216,A4)
00135    23•          WRITE(6,       501)     PAYROL
00143    24•      501 FORMAT (1X, 'NAME=', 3(A6,A4), ' REG=', I6, ' OVER=', I6)
00144    25•          ST=1
00145    26•          CALL NTRAN (    35,1,        9,     PAYROL,ST)
00146    27•          CALL CHECKS (ST, 5     3)
00147    28•          GO TO      4
00150    29•        3 WRITE (6,        5)
00152    30•        5 FORMAT(1X,11HEND OF FILE)
00153    31•          CALL  RUNERR
00154    32•        4 CONTINUE
00155    33•      600 CONTINUE
00157    34•          CALL  NTRAN(    35, 10)
00160    35•          IXGET=0
00161    36•          ST=1
00162    37•          ANS   (1)=0
00163    38•        6 IXGET=IXGET+1
00164    39•          CALL  NTRAN(    35,2,        9,     PAYROL,ST)
00165    40•          CALL CHECKS (ST, 5     7)
00166    41•          IF (        TESTRL(1,'LAST  ',LAST  ,'LEAR'))GOTO     8
00170    42•          GO TO      6
00171    43•        8 CALL SUBSTR(PAYROL,    9,    1,   36,     ANS   ,   36)
00172    44•        7 CONTINUE
00173    45•          WRITE(6,       502)     ANS
00201    46•      502 FORMAT (1H0,1X, 'NAME WHERE LAST EQ LEAR =', 7A6)
00202    47•          CALL  NTRAN(    35, 10)
00203    48•          IXGET=0
00204    49•          ST=1
00205    50•          ANS   (1)=0
00206    51•        9 IXGET=IXGET+1
00207    52•          CALL  NTRAN(    35,2,        9,     PAYROL,ST)
00210    53•          CALL CHECKS (ST, 5    10)
00211    54•          IF (        TESTRL(3,'REGULR',REGULR,700   ))GOTO    11
00213    55•          GO TO      9
00214    56•       11 CALL SUBSTR(PAYROL,    9,    1,   36,     ANS   ,   36)
00215    57•       10 CONTINUE
00216    58•          WRITE(6,       503)     ANS
00224    59•      503 FORMAT (1H0,1X,'NAME WHERE REG GT 700=', 7A6)
00225    60•          STOP
00226 •01AGNOSTIC•   CONTROL CAN NEVER REACH THE NEXT STATEMENT
00226    61•          I=1
00227    62•          IXGET=0
00230    63•          ST=1
00231    64•          ANS   (1)=0
00232    65•       12 IXGET=IXGET+1
00233    66•          CALL  NTRAN(    35,2,        9,     PAYROL,ST)
00234    67•          CALL CHECKS (ST, 5    13)
00235    68•          IF (        TESTRL(3,'OVER  ',OVER  ,500   ))GOTO    14
```

```
00237    69•          GO TO     12
00240    70•       14 CALL SUBSTR(PAYROL,    9,    1,   36,     ANS   (1•  61,  36)
00241    71•          ANS   (11=  ANS   (11•1)
00242    72•       13 CONTINUE
00243    73•          STOP
00244    74•     1    CONTINUE
00245    75•          ILIM =    10
00246    76•          J (         1      ,      (1  =        0
00247    77•          J (         1      ,      21  =        2
00250    78•          J (         1      ,      31  =        2
00251    79•          J (         1      ,      41  =        0
00252    80•          J (         1      ,      51  =        9
00253    81•          J (         1      ,      6)  =       6H@@@@@@
00254    82•          J (         1      ,      71  =       48
00255    83•          J (         1      ,      81  =        0
00256    84•          J (         2      ,      11  =        1
00257    85•          J (         2      ,      21  =        4
00260    86•          J (         2      ,      31  =        3
00261    87•          J (         2      ,      41  =        1
00262    88•          J (         2      ,      51  =        6
00263    89•          J (         2      ,      61  =       6H@@@@@@
00264    90•          J (         2      ,      7)  =       36
00265    91•          J (         2      ,      81  =        0
00266    92•          J (         3      ,      11  =        2
00267    93•          J (         3      ,      21  =        6
00270    94•          J (         3      ,      3)  =        0
00271    95•          J (         3      ,      41  =        2
00272    96•          J (         3      ,      51  =        4
00273    97•          J (         3      ,      61  =       6H@@@@@@
00274    98•          J (         3      ,      71  =       12
00275    99•          J (         3      ,      8)  =        0
00276   100•          J (         4      ,      1)  =        2
00277   101•          J (         4      ,      2)  =        8
00300   102•          J (         4      ,      31  =        0
00301   103•          J (         4      ,      4)  =        2
00302   104•          J (         4      ,      51  =        5
00303   105•          J (         4      ,      61  =       6H@@@@@@
00304   106•          J (         4      ,      71  =       12
00305   107•          J (         4      ,      81  =       12
00306   108•          J (         5      ,      11  =        2
00307   109•          J (         5      ,      21  =       10
00310   110•          J (         5      ,      3)  =        0
00311   111•          J (         5      ,      4)  =        2
00312   112•          J (         5      ,      51  =        3
00313   113•          J (         5      ,      61  =       6H@@@@@@
00314   114•          J (         5      ,      71  =       12
00315   115•          J (         5      ,      81  =       24
00316   116•          J (         6      ,      11  =        1
00317   117•          J (         6      ,      2)  =       12
00320   118•          J (         6      ,      31  =        2
00321   119•          J (         6      ,      4)  =        1
00322   120•          J (         6      ,      51  =        2
00323   121•          J (         6      ,      6)  =       6H@@@@@@
00324   122•          J (         6      ,      71  =       12
00325   123•          J (         6      ,      81  =       36
00326   124•          J (         7      ,      11  =        2
00327   125•          J (         7      ,      21  =       14
00330   126•          J (         7      ,      31  =        0
00331   127•          J (         7      ,      4)  =        6
00332   128•          J (         7      ,      5)  =        8
00333   129•          J (         7      ,      61  =       6H@@@@@@
00334   130•          J (         7      ,      71  =        6
00335   131•          J (         7      ,      81  =       36
00336   132•          J (         8      ,      1)  =        2
00337   133•          J (         8      ,      21  =       16
00340   134•          J (         8      ,      3)  =        0
00341   135•          J (         8      ,      41  =        6
00342   136•          J (         8      ,      51  =        7
00343   137•          J (         8      ,      61  =       6H@@@@@@
00344   138•          J (         8      ,      71  =        6
00345   139•          J (         8      ,      8)  =       42
00346   140•          J (         9      ,      11  =        0
00347   141•          J (         9      ,      21  =       18
00350   142•          J (         9      ,      3)  =        0
00351   143•          J (         9      ,      41  =        0
00352   144•          J (         9      ,      51  =       10
00353   145•          J (         9      ,      61  =       6H@@@@@@
00354   146•          J (         9      ,      7)  =       36
00355   147•          J (         9      ,      81  =        0
00356   148•          J (        10      ,      11  =        0
00357   149•          J (        10      ,      21  =       20
00360   150•          J (        10      ,      31  =        0
00361   151•          J (        10      ,      41  =        0
00362   152•          J (        10      ,      51  =        0
00363   153•          J (        10      ,      61  =       6H@@@@@@
00364   154•          J (        10      ,      71  =        6
00365   155•          J (        10      ,      81  =       36
00366   156•          SYMBOL(          1)  =       6H@@@@@@
00367   157•          SYMBOL(          2)  =       6HPAYROL
00370   158•          SYMBOL(          3)  =       6H@@@@@E
00371   159•          SYMBOL(          4)  =       6HNAME
00372   160•          SYMBOL(          5)  =       6H@@@@@J
00373   161•          SYMBOL(          6)  =       6HFIRST
00374   162•          SYMBOL(          7)  =       6H@E@@@#
00375   163•          SYMBOL(          8)  =       6HMIDLE
00376   164•          SYMBOL(          9)  =       6H@E@@@A
00377   165•          SYMBOL(         10)  =       6HLAST
00400   166•          SYMBOL(         11)  =       6H@E@@@
00401   167•          SYMBOL(         12)  =       6HSALARY
00402   168•          SYMBOL(         13)  =       6H@@@@A@A
00403   169•          SYMBOL(         14)  =       6HREGULR
00404   170•          SYMBOL(         15)  =       6H@@@@A@8
00405   171•          SYMBOL(         16)  =       6HOVER
00406   172•          SYMBOL(         17)  =       6H@@@@@@C
00407   173•          SYMBOL(         18)  =       6HANS
00410   174•          SYMBOL(         19)  =       6H@E@=@D
00411   175•          SYMBOL(         20)  =       6HDUMMY
00412   176•          SYMBOL(         21)  =       6H@@@@@@E
00413   177•          SYMBOL(         22)  =       6H@@@@@@@
00414   178•          FILNAM(          1)  =       6H@@@@@A
00415   179•          FILNAM(          2)  =       6HPAYROL
00416   180•          FILNAM(          3)  =       6H@@@<@@D
00417   181•          FILNAM(          4)  =       6H@@@@@@@
00420   182•          GO TO     2
00421   183•          END
```

```
      END OF UNIVAC 1108 FORTRAN V COMPILATION.     1 *DIAGNOSTIC* MESSAGE(S)
PHASE 1 TIME =    1 SEC.
PHASE 2 TIME =    0 SEC.
PHASE 3 TIME =    0 SEC.
PHASE 4 TIME =    0 SEC.
PHASE 5 TIME =    1 SEC.
PHASE 6 TIME =    0 SEC.

TOTAL COMPILATION TIME =    2  SEC


 NAME=PAUL                KRCS        REG=100000 OVER=120000
 NAME=ZBGIN      NEW      PRZYBYLSKI  REG=101000 OVER=100000
 NAME=TRUMAN     E.       TURNIPSEED  REG= 60000 OVER=  7000
 NAME=PEACE               HAPPINESS   REG=520000 OVER=880000
 NAME=CRYSTAL    SMANDA   LEAR        REG=350000 OVER=     0
 NAME=PRAISE     GOD      BAREBONES   REG=640000 OVER=960000
 NAME=IMA        A.       HOGG        REG=442500 OVER=800000

  NAME WHERE LAST EQ LEAR =CRYSTAL     SMANDA      LEAR
  NAME WHERE REG GT 700=PAUL                       KRCS


@ EOF                                          03 JUN 71          14:10:23.794
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FORM NBS-114A (1-71)

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7. AUTHOR(S): Elizabeth Fong

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15. SUPPLEMENTARY NOTES

16. ABSTRACT (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)

DRL (Data Retrieval Language) is a high-level programming language for information retrieval. The language includes a data description language which can describ fixed-length hierarchical data structures, and DRL includes a data retrieval statement whereby a user can retrieve data by specifying conditions on to the data value. DRL also has an environment declaration statement in which the user can indicate specific peripheral devices by unit number for files. The rest of the language consists of an operation repertory of input-output functions and other data manipulations.

DRL is implemented as a preprocessor to FORTRAN V on the UNIVAC 1108. Keywords act as triggers and are replaced by blocks of FORTRAN code.

The purpose of this project is to investigate the design of an information retrieval language to handle a generalized data base. The DRL system consists of a se of primitives utilizing both compile-time macros and run-time subroutines. These primitives are embedded in a high-level procedure-oriented programming language--the "host language"--FORTRAN in this case. These primitives form a base upon which a class of languages can be defined.

17. KEY WORDS (Alphabetical order, separated by semicolons)

Data base; data retrieval; data structure; information storage and retrieval; language extension; preprocessor; programming language.

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POSTAGE AND FEES PAID
U.S. DEPARTMENT OF COMMERCE